13
Scientific Understanding of Ecosystem Services

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Opposite page: Mangrove clearing for port construction at Lamu, Kenya. © Mike Olendo.

HUMAN DEPENDENCE ON ECOSYSTEM SERVICES

Ecosystem services (Fig. 13.1) are the range of benefits that people obtain from ecosystems (Biggs and others, 2004). While the emphasis in scientific discourses has been more often on goods, which provide direct benefits to humans, these services are more than just goods, and include critical buffering, regulating and life-supporting services or processes, which are commonly neglected or taken for granted by society (Shackleton and others, 2008). Ecosystems also provide less tangible benefits such as recreational, aesthetic, cultural and spiritual values that are important in fulfilling people's emotional and psychological needs (UNEP/IISD 2004). These services are also produced by modified, agricultural and urban ecosystems, albeit with particular trade-offs between specific services.

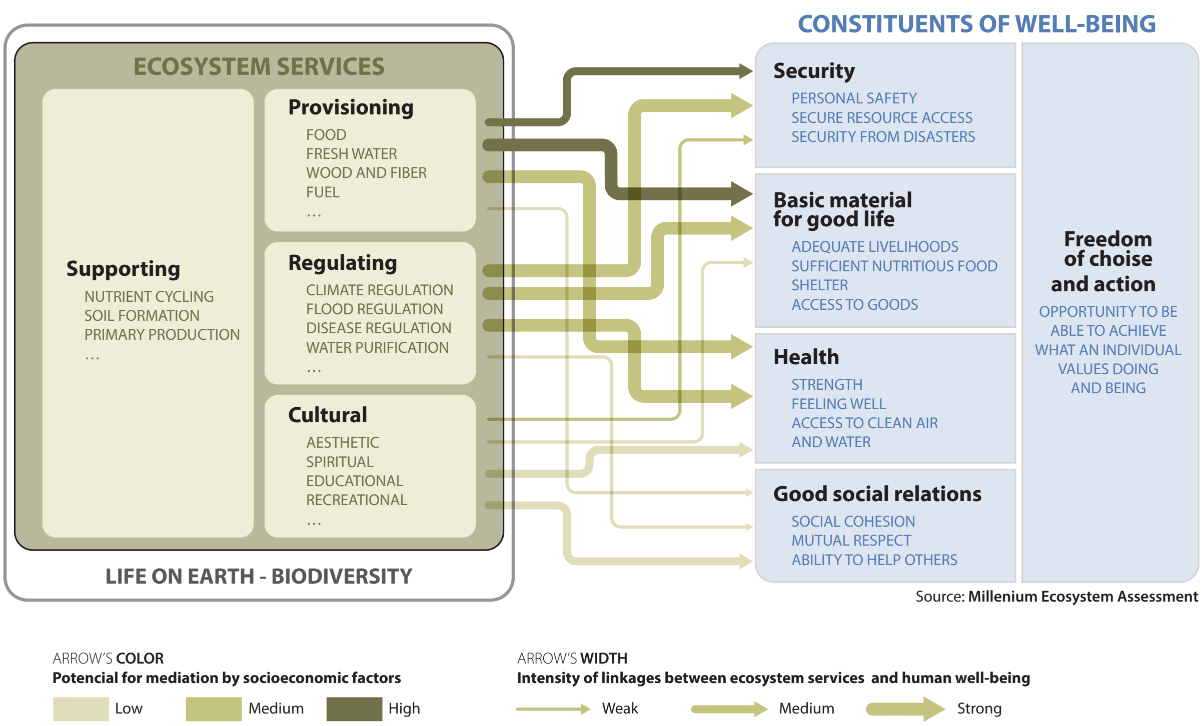

Figure 13.1. Different categories of ecosystem services and their contribution to human well-being. Source: MEA 2005.

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Humans have always depended upon natural ecosystems to supply a range of services useful for their survival and well-being. The level of dependency has however kept evolving over the years in consonance with the state of development in different countries. People in least developed countries are thus more directly dependent on ecosystem services making them highly vulnerable when natural ecosystems are degraded (WRI 2005).

The main constituents of human well-being derived from ecosystem services include security (which deals with personal safety and security from disasters eg coastal protection), materials for a decent life (livelihoods and shelter), health (eg feeling of well-being and access to clean water) and good social relations (social cohesion, respect and ability to help others), which are all underpinned by freedom of choice and action (MEA 2005).

Some services are of a public nature with an underlying assumption that such are available to everyone (low exclusivity) eg clean air, good view of nature, coastal protection, clean beaches. Two general characteristics underpin such public services (Bolt and others, 2005; Fig. 13.2):

i) Everybody can use them without depleting their availability for others (economists call this 'non-rivalry') and

ii) It is very difficult, technically, to prevent people from using them. In other words, public goods are 'non-excludable'.

The problem with public goods is that everyone has a relatively small incentive to provide the good. Therefore people will tend to free-ride on others providing it and enjoy it for free. As a consequence, public goods are generally under-provided and state action is usually required to solve the problem (Bolt and others, 2005).

Brown and others (2008) observed that various trends and patterns underpin access to utilization of ecosystem services especially by the poor in society, and include the following:

• The poor have had minimal impacts overall on changes in ecosystem services and have also received a disproportionately small share of the benefits of ecosystem services in coastal and marine systems. However, in particular locations, the unsustainable use of these services by poor stakeholders with limited options is a major driver of degradation of ecosystem services.

• The poor prioritise provisioning services over all other ecosystem services, and identify the most important benefits from these services as being cash, food and employment, which are not explicitly and separately considered in the Millennium Assessment conceptual framework (MEA 2005).

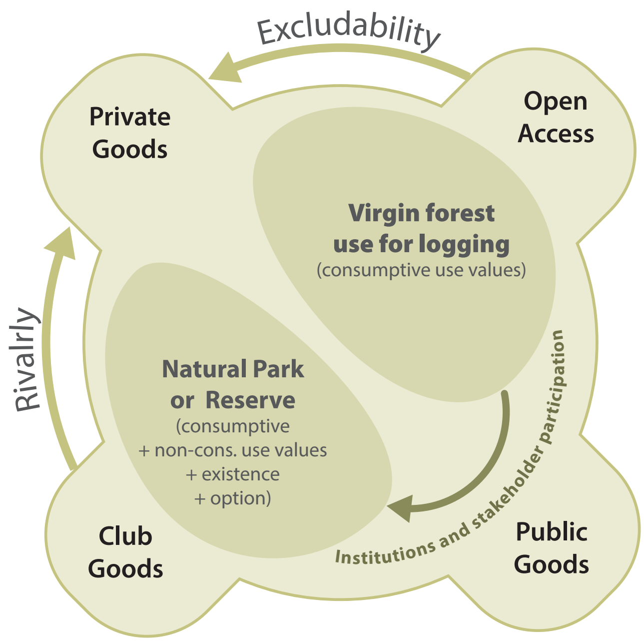

Figure 13.2. Public and private goods: Rivalry and excludability. Source: Bolt and others, 2005.

• Many other ecosystem services are not of direct relevance to the poor and have no straightforward or simple role in alleviating poverty. Supporting services for the provisioning and regulating services are recognized by poor people. Very often their role in protecting livelihoods is extremely important, for example providing the basis to support provisioning services, in protecting homes, providing clean water and moderating environmental risks. However, the role of supporting services in active poverty alleviation is not direct and sometimes much less clear than provisioning services.

• There are few examples of mechanisms to enhance ecosystem services and alleviate poverty; and very little precise information to show exactly how ecosystem services can contribute towards poverty alleviation.

• There is evidence of shifting patterns of dependence on ecosystem services and shifting vulnerabilities to change in ecosystem services. This relates to where poor people live – for example, increasing numbers of people are concentrated in urban coastal areas in many countries and regions; how people construct their livelihoods – related to patterns of diversification and specialisation and movements in and out of fishing; processes of globalisation and changing access and exploitation, particularly penetration by global markets (eg aquaculture transforming coast-

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line, and industrial fishing exploiting sea), each of which potentially puts poor people at risk (Brown and others, 2008).

LINK BETWEEN DRIVERS OF CHANGE, ECOSYSTEM SERVICES AND HUMAN WELL-BEING

The way that coastal ecosystem services are distributed and degraded is currently making the poor poorer, more vulnerable and more marginalized thus undermining their ability and incentive to contribute to preserving the ecosystems services that sustain them (Newton and others, 2007).

The Millennium Ecosystem Assessment (MEA 2005) and others (Jackson and others, 2001, Donner and Potere 2007, Adger and others, 2005) have demonstrated how ecosystems and the services they support are under increasing pressure from a range of drivers; they are being seriously degraded; and, if trends persist, will be unable to support human well-being as in the past. Future pressures from population increases in coastal areas, pollution, aquaculture development, greater human mobility, and the spread of invasive species are likely to further exacerbate these trends (Brown and others, 2008). More recently, climate change has exacerbated the impact of anthropogenic pressures to aggravate degradation of natural resources with a resultant impact on dependent livelihoods (Goreau and others, 2000, Obura 2002, McClanahan and others, 2005, Bosire and others, 2010, IPCC 2014). Implications of climate change on livelihoods in the WIO region are elaborated on in Box 13.1.

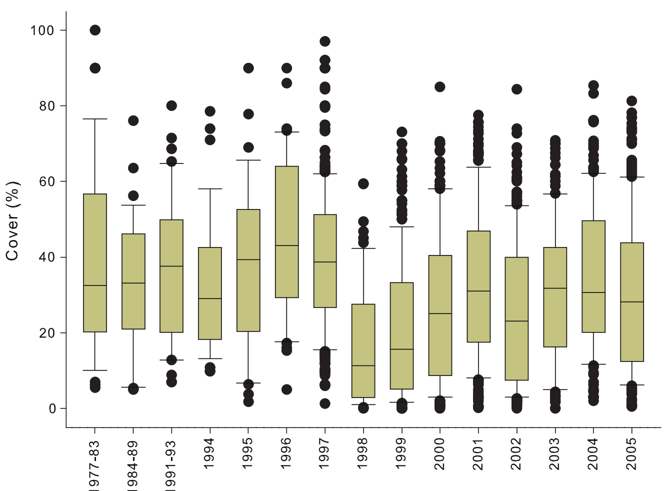

Figure 13.3. Yearly temporal coral cover trends throughout the Indian Ocean region (Ateweberhan and others, 2011).

Past elevated sea surface temperature (SST) episodes have led to widespread coral bleaching in the region (McClanahan and others, 2005, Obura 2002, Ateweberhan and others, 2011) and thus compromised supporting and regulating services provided by coral ecosystems. Fig. 13.3 shows the impact of the bleaching especially in 1998 immediately after the ENSO event and recovery post-event. During this phenomenon, SST was elevated by 1°C, which precipitated widespread coral bleaching.

Brown and others (2008) noted that many of the drivers of change within marine and coastal social-ecological systems lie outside the strict boundaries of the coastal zone and seascape. They concern global economic processes, markets and trade; economic policy and environmental governance; and land use and resource management in terrestrial systems (Maina and others, 2013). They therefore recommended that there is a critical need to understand the interactions between drivers and impacts of change across coastal, marine terrestrial and global systems in order to better devise and implement integrated policy and responses to support ecosystem services and poverty alleviation (Fig. 13.4).

From the Global Living Plant Index (WWF and ZSL 2014), it is clear that the overall integrity of ecosystems has been deteriorating over time despite huge global conservation efforts. A decline of 52 per cent of the earth's species has been reported since 1970, while for marine biodiversity, a reduction of 39 per cent occurred within the same period (Fig. 13.5). This has been compounded by the ever-increasing global ecological footprint on natural resources (Fig. 13.6), which has exceeded the earth's bio-capacity (WWF and ZSL 2014).

AMELIORATING LOSS/IMPOVERISHMENT OF ECOSYSTEM SERVICES

Numerous international initiatives are focusing on restoring ecosystem services in areas affected by land-use changes and biodiversity loss to ensure return of lost or impoverished services (Bosire and others, 2004, Bosire and others, 2008, GEF 2009, Tengberg and Torheim 2007). There is also a growing interest in regulating ecosystem services related to climate change, such as carbon sequestration in different types of ecosystems, including opportunities to protect carbon stocks in tropical forests, eg through Reduction of Emissions from Deforestation and forest Degradation (REDD)

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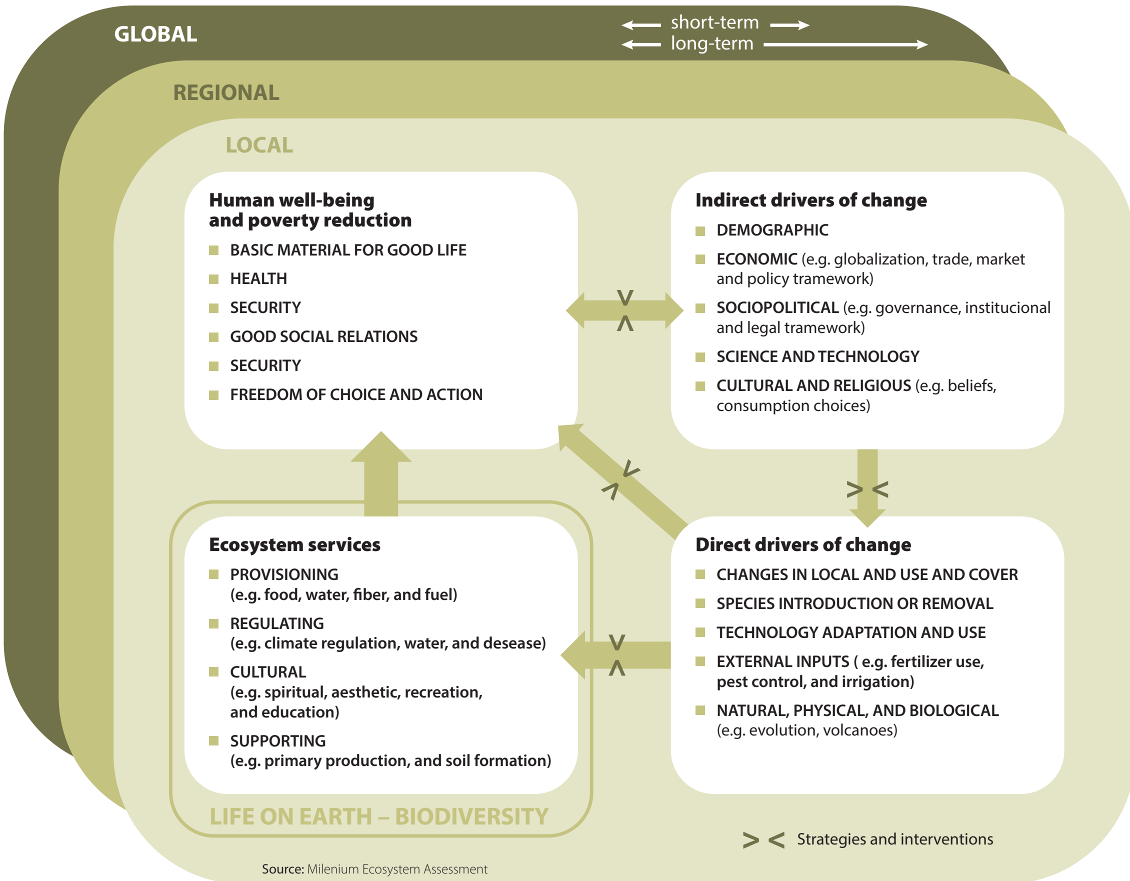

Figure 13.4. Link between ecosystem services, human well-being and drivers of ecosystem change (MEA 2005).

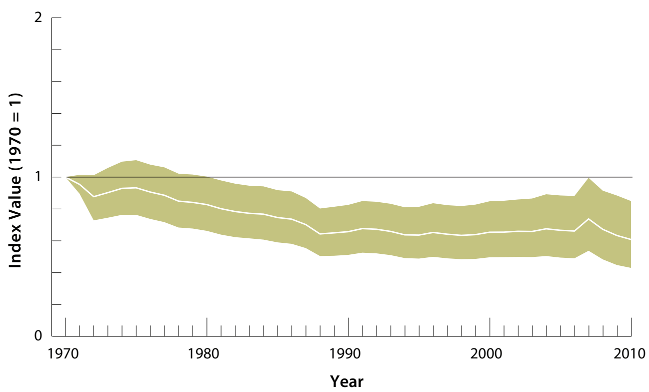

Figure 13.5. Marine Living Planet Index (WWF and ZSL 2014).

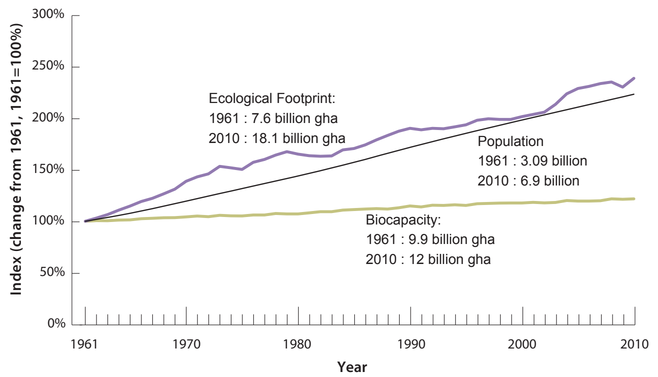

Figure 13.6. Population growth driving the global ecological footprint (WWF and ZSL 2014)

(Miles and Kapos 2008, Donato and others, 2012). An example of a Payment for Ecosystem Services (PES) scheme in the region is the Mikoko Pamoja Project at Gazi Bay, Kenya (Huxham 2012), which is bringing in about US$ 12 000 per annum to Gazi community in support of mangrove conservation (see Box 13.2). Potential exists for expanding such initiatives within Kenya and the WIO region as well. Reduced Emissions from Deforestation and Degradation (REDD+) is a financial incentives-based climate change mitigation initiative designed to compensate national governments and sub-national actors in return for demonstrable reductions in carbon emissions from deforestation and degradation and enhancements of terrestrial carbon stocks (Agrawal and others, 2011). Maina and others (2013) conducted a study simulating river flow and sediment supply in four watersheds adjacent to Madagascar's major coral reef

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ecosystems for a range of future climate change projections and land-use change scenarios. They found that deforestation rates far outweigh future climate change impacts on coral. This is as a result of increased sedimentation to coral reefs precipitated by upland deforestation. Management planning which reduces upland deforestation will not only improve the ecological integrity of marine ecosystems downstream, but also help in reducing global GHGs as deforestation contributes about 20 per cent of all global emissions (IPCC 2007). Although it is a generally well-established and accepted maxim, applicable across different ecosystems and resources, McClanahan and others (2011) found that in coastal fisheries in nine WIO countries, different management regimes have a direct bearing on resource productivity and sustainability, thus suggesting that key trade-offs are required to achieve different fisheries and conservation goals. These varying management regimes also determine the vulnerability (or otherwise) of ecosystems to climate change with protected areas or areas with regulated access being more resilient (Cinner and others, 2013). More investments are thus required for climate change mitigation research and enhanced management of the region's coastal and marine ecosystems for improved ecosystem integrity and continued provision of requisite ecosystem services.

Ecosystem restoration has proven critical in returning ecosystem goods and services, when there is positive recovery, especially for mangrove ecosystems (Kairo and others, 2002, Bosire and others, 2004, Bosire and others, 2008). It is important that appropriate restoration pathways are explored in terms of species and site suitability (see Text Box 3) to enhance recovery (Bosire and others, 2008). Evaluation of restoration projects is also important to determine whether

BOX 13.1. SOCIO-ECONOMIC IMPACTS OF CLIMATE CHANGE

Mangrove die-back due to massive sedimentation at Mwache Creek, Kenya. © Jared Bosire.

Africa will be most impacted by climate variability and change (Allison and others, 2005; Boko and others, 2007). For instance by 2020, it is projected tha between 75 million to 250 million people in Africa will be exposed to increased water stress due to prevalent droughts. This will in turn have profound impact on food production in a region, wich is already food insecure. Coral bleching, mangrove die-back, ocean acidification and elevated temperature will significantly reduce fisheries production, thus aggravating food insecurity in the WIO region (Boko and others, 2007; Cinner and others, 2009). High intensity storms and sea level rise will have localized but considerable impacts, which will threaten coastal developments, farming activities, and even human lives. Migration of communities from vulnerable areas to safer areas has implications on the social fabric. Changing environmental factors may favour proliferations of disease vectors e.g. mosquitoes wich will aggravate disease incidence and threaten the health of local communities.

Low lying coastal cities are also threatened by sea level rise, although the spatial magnitude and extent of this threat will need to be quantified. Where the situation allows, coastal developments must incorporate sea level rise projections in terms of setback lines, avoidance of vulnerable areas and provision of migration corridors for mangroves for landward transgression. Flooding also causes extensive damage to infrastructure leading to elevated development costs, which become a burden to national development. A regional assessment analyzing vulnerability of coastal cities to sea level rise and flooding will be necessary. Developmental gains made by governments of the region stand to be gravely compromised and overall development in the longterm retarded. This is especially due to high dependence on the agricultural sector (which is highly vulnerable in the face of changing climate), the prevalence of poverty and inadequate preparednes to disasters (Bosire and others, 2010).

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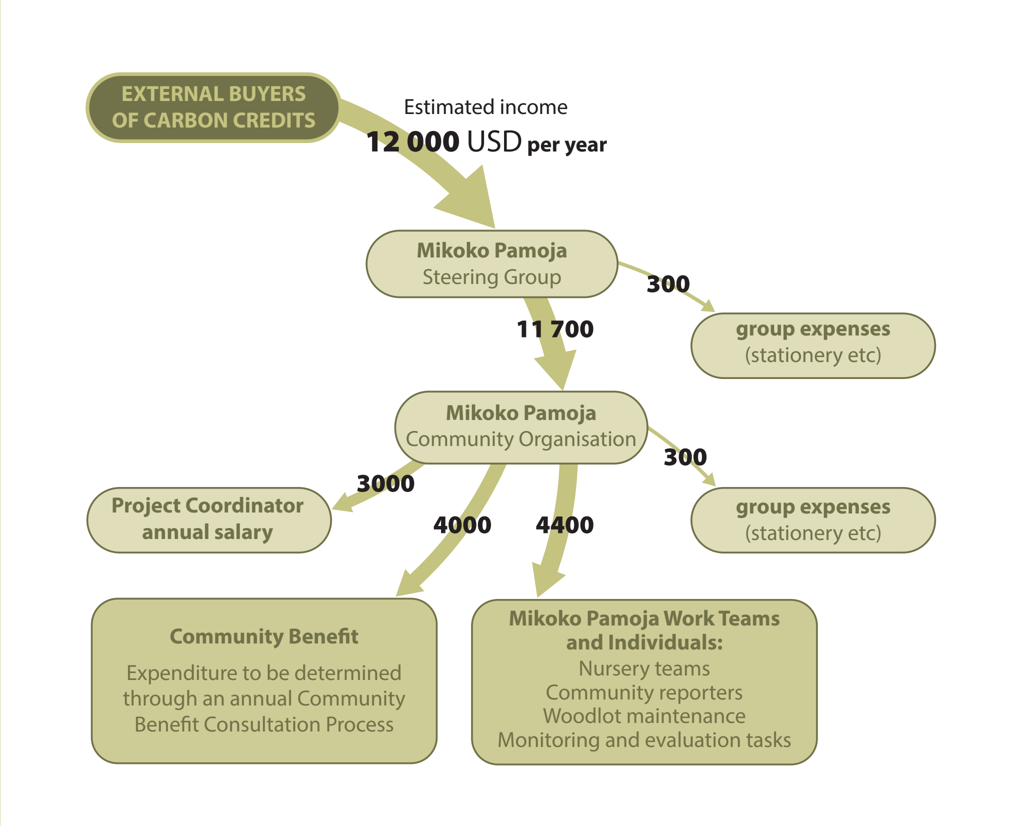
BOX 13.2. MANGROVE CONSERVATION AND CARBON OFFSET PROJECT



Revenue shering between different activities under *Mikoko Pamoja* Project (Huxham 2012).

***Mikoko Pamoja* Mangrove Conservation and Carbon Offset Project:** This is a pioneering project aiming to save threatened African mangroves and pilot small-scale atmospheric carbon offset. This small-scale project, which is part of wider global efforts on climate change mitigation initiatives was launched on 3 October 2013 at Gazi Bay, Kenya for mangrove conservation and support of community services. *Mikoko Pamoja*, meaning 'Mangroves together' in Swahili, aims to generate and sell carbon credits to companies and individuals looking to improve their green credentials. The project is therefore expected to generate US$ 12 000 per year, covering project costs (70 per cent) and with 30 per cent going to the local community. The carbon credits from the projects are marketed under the Plan Vivo Foundation (Standard), a charity that helps ensure that carbon offset schemes deliver genuine ecological benefits. An initial 117 hectares of mangroves has been set aside for the project with additional expected through improved forest management and restoration of degraded areas. Leakage is being managed through the establishment of *Casuarina* plantations (Huxham 2012).

inherent functions do recover and, where possible, conduct economic valuation of such systems (Kairo and others, 2009).

However, cultural ecosystem services have generally been neglected by these initiatives due to the need for different scientific competencies and methods, including a historical perspective in the analysis. Interdisciplinary approaches are therefore needed to improve the understanding of cultural ecosystem services that takes into account the dynamic nature of human–environment interactions and possible synergies and trade-offs between cultural, supporting, provisioning and regulating ecosystem services.

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BOX 13.3. ECONOMIC ANALYSIS OF A RESTORED MANGROVE PLANTATION IN KENYA

Community mangrove restoration at Mwache Creek, Kenya. © Jared Bosire.

Data and examples on total economic valuation (TEV) for restored coastal ecosystems are rare or completely lacking. There is an example from Kenya, where there has been a long history of successful mangrove restoration. Economic analysis of mangrove reforestation was conducted in a replanted *Rhizophora mucronata* forest at Gazi Bay, Kenya. Major goods and services from the 12-year plantation were identified as: firewood and building poles, coastal protection, ecotourism, research and education, carbon sequestration and on-site fisheries. The net value of extractable wood products was estimated at US$ 379.17/ha/a. For non-extractable products, however, the net value ranged from US$ 44.42/ha/a in carbon sequestration to US$ 1 586.66/ha/a in coastal protection. The total economic value of the 12-year-old *Rhizophora* plantation was therefore US$ 2 902.87/ha/a. Since most of these benefits cannot be internalized, there is need for governments to promote community efforts in mangrove reforestation through finding ways of marketing ecosystem services of the replanted forests (Kairo and others, 2009).

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